

2.3 Aircraft Safety Program Area Description

Mission

The mission of the Aircraft Safety program is to provide a safe global air transportation system by establishing safety standards and acceptable practices through development of technical information, tools, and technology to ensure safe operation of the civil aircraft fleet.

This program addresses the many hazards that face all aircraft in flight, as well as special hazards that apply to select portions of the civil aircraft fleet. For example, older aircraft are more susceptible to structural problems associated with fatigue and corrosion. New aircraft—with their digital flight control and avionics systems, associated imbedded software, and construction of new non-metallic materials—present significant challenges in certification, continued airworthiness, and operation. However, all aircraft, old or new, must deal with the hazards of adverse weather.

Intended Outcomes

The Aircraft Safety program supports the FAA's safety mission goal: by 2007, reduce U.S. aviation fatal accident rates by 80 percent from 1994-1996 levels.

The Aircraft Safety program focuses on improving system safety through the following research programs:

- Support aging aircraft by developing technologies, procedures, and practices that ensure the continued airworthiness of aircraft structures and aircraft mechanical and electrical systems in the civil fleet.
- Prevent catastrophic failure by developing technologies and methods that will assess the risk and prevent defects, failures, and malfunctions of aircraft, aircraft components, and aircraft systems that could result in catastrophic failure of the aircraft.
- Promote flight safety and reduce the effects of atmospheric hazards by addressing atmospheric hazards in the design, development, and certification process.
- Improve propulsion and fuel systems by enhancing the airworthiness, reliability, and per-

formance of civil turbine and piston engines, their propellers, fuels, and fuel management systems.

- Support fire research and safety by developing near-term fire safety improvements to prevent uncontrollable in-flight fires and increase post-crash fire survival rates and conducting long-range research to develop ultra fire-resistant cabin materials.
- Promote advanced materials and structural safety by ensuring both the safety of U.S. civil aircraft constructed of advanced materials and passenger survival in the event of an accident.
- Enhance aviation safety risk analysis by improving FAA and industry measurement of and accountability for safety performance through risk assessment and operational indicators and sharing safety-related data.

Aircraft safety improvements will reduce fatalities and injuries, reduce hull losses, improve aircraft designs, and impact maintenance and inspection procedures. Potential significant safety benefits include:

- Reduce the approximately 30 to 35 U.S. fire fatalities per year and 135 worldwide, in otherwise survivable accidents. At an estimated savings of \$2.7 million per life, saving 24 lives per year would pay for the entire aircraft safety research, engineering, and development effort.
- Use a more reliable airframe inspection technique that has been approved as an alternate inspection technique for detecting corrosion at the juncture of wing and fuselage on DC-9's. The new technique will save over 700 person-hours per inspection, compared to the current inspection method. The technique also requires less disassembly of the aircraft part to conduct the inspection, resulting in less chance for damage during disassembly and reassembly. One airline estimates that by using the new inspection technique, it can save over \$2 million over the maintenance cycle for its fleet of DC-9s

Program Area Outputs

The FAA establishes rules for aircraft certification, operation, inspection, maintenance and repair, and publishes advisory circulars to outline acceptable means of meeting the rules. The agency also disseminates technical information in various forms to its airworthiness inspectors and to industry to improve aircraft construction and maintenance practices. Technical information is developed to establish criteria for safety systems, such as seat restraints and protective breathing equipment.

The primary objective is to improve system safety based on elimination of causal factors related to aircraft and flight hazards. Aircraft safety research provides the technical information necessary to support agency outputs.

Aircraft Safety program research customers include aviation manufacturers and aircraft and avionics maintenance facilities, aircraft operators, and the general public who use commercial air transportation. The safety research program supports customer requirements by providing tools that enable demonstration of compliance and development of advisory information to ensure the safety of the flying public. Aviation safety research sponsors are FAA personnel in Flight Standards (AFS) and Aircraft Certification (AIR). The aircraft safety program supports sponsor requirements by providing the research to aid rulemaking and regulation development and by developing technical data and guidance material to develop standards, rules, and regulations.

Program Area Structure

The Aircraft Safety program includes research in a wide range of areas related to aircraft and passenger safety. It focuses on eliminating hazards to the air transportation system, by both preventing accidents from happening and by mitigating the effects of those accidents that do occur. Prevention and mitigation activities include:

- Accident and incident prevention
 - Structural integrity (preventing aircraft structural failure)
 - Propulsion systems (ensuring reliable aircraft power)
 - Flight safety (minimizing operational hazards)

- Mechanical and electrical system reliability and integrity (reducing aircraft systems failure)
- Accident and incident mitigation
 - Crashworthiness (maximizing crash survivability and escape)
 - Fire safety (preventing fire and fire fatalities)

Customer/Stakeholder Involvement

Research programs within the Aircraft Safety program directly support the Aviation Safety Plan (February 1996) through research supporting priority issues associated with the following workshops: "Safety Data Collection and Use," "Application of Emerging Technologies," and "Aircraft Maintenance Procedures and Inspection."

The Subcommittee on Aircraft Safety, of the FAA Research, Engineering, and Development Advisory Committee, periodically reviews the Aircraft Safety program area. The most recent review was completed in 1999. The program described here is fully responsive to the advice of the subcommittee.

The FAA's primary mission, as originally mandated in Sections 312 and 316 of the Federal Aviation Act of 1958, is to develop, modify, test, and evaluate systems, procedures, facilities, and devices to meet the needs of safe and efficient aviation.

The FAA's research mission was expanded when Congress passed the legislation known as the Aviation Safety Research Act of 1988 (Public Law 100-591). The act mandates that the FAA: "Undertake or supervise research to develop technologies and to conduct data analysis for predicting the effects of aircraft design, maintenance, testing, wear, and fatigue on the life of aircraft and on air safety, to develop methods of analyzing and improving aircraft maintenance technology and practices." The 1988 act also authorized the FAA to generate technology breakthroughs where technology gaps need to be closed while emphasizing the importance of long-range research.

Passage of the Aircraft Catastrophic Failure Prevention program under the Omnibus Reconciliation Act of 1990 (Public Law 101-508) further expanded the FAA research mission. While the FAA

mission originally focused on airplane improvements, the 1990 amendment added proactive research to make airplanes free from catastrophic failure.

In 1998 the FAA published the Aging of Non-structural Systems Plan in response to the Gore Commission's recommendation. Research is being developed as recommended in that plan.

Safety research will reduce the hazards of operating aircraft, thus providing a higher level of safety. Much of the technology developed will also enhance U.S. aviation industry competitiveness for both manufacturers and operators.

Accomplishments

Research results are disseminated to the agency (aircraft certification and flight standards) and to industry (aircraft manufacturers, operators, and maintainers) as:

- Technical and regulatory guidance for airframe maintenance in the form of handbooks, technical bulletins, aircraft-specific inspection requirements, advisory circulars, and rules.
- Validated instrumentation, procedures, and methodologies for aircraft maintenance, inspection, and repair.
- Reports that provide relevant technical information for aircraft manufacturers, operators, and maintainers.
- Technical data provided to the community at conferences, symposia, workshops, and hardware/software prototype demonstrations.
- Criteria to support certification of aircraft and their safety and emergency equipment.
- Technical data to support regulatory oversight in inspection, maintenance, repair, and standards development.
- Training materials in areas such as damage tolerance requirements, corrosion control, inspection, and maintenance and repair.

Several prototype inspection devices developed tested, and validated in this research program have shown significant potential for more accurate, reliable flaw detection in the airframe and in engines. One method for engine component inspection in particular has shown a four-fold improvement in sensitivity for detecting the type of

flaw that led to the 1989 Sioux City accident that killed 211 people.

Numerous advisory circulars (AC) have been developed for a wide range of aviation safety-related activities, including design of composite structures, corrosion control, aircraft deicing, inspection, and repair. ACs controlling aircraft ground deicing for both large transport airplanes (AC 120-58, 9/92) and smaller commuter airplanes (AC 135-17, 12/94) are aimed at ensuring the safe operation of large airplanes and air taxis during icing conditions. These ACs provide guidelines for developing adequate deicing procedures.

Technical data have been developed to support standards development, the certification of aircraft and aircraft components, and the continued airworthiness of aircraft. For example, an enhanced ultrasonic technique has been developed and implemented to detect defects in the titanium billet materials used to manufacture engine rotating components. The system has demonstrated a four-fold improvement in defect detection compared to the current inspection and has detected defects that were missed by the conventional inspection system. Three billets production locations have inspected over 5.5 million pounds of titanium billet using the advanced technique. The new inspection technique will decrease the possibility of engine failure due to undetected flaws and increase the reliability and efficiency of inspection procedures for engine critical components. An industry-wide ultrasonic billet inspection specification based on the new technique was developed and approved by the Society of Automotive Engineers (SAE) Committee K and the SAE Aerospace Council.

R&D Partnerships

Program activities are closely coordinated with related initiatives underway within other government agencies, including the Department of Energy (DOE), DOD, and NASA. Formal agreements of cooperation are in place with the Air Force, Army, Navy, NASA, DOE, and in developing standardization data for materials in MIL-HDBKS 5 and 17.

International agreements are in place with government agencies and research laboratories in the

United Kingdom, the Netherlands, France, Italy, Australia, Canada, and Russia.

Numerous grants are in place with universities and research laboratories to leverage their interests and capabilities. Partnerships have been established with academia and industry through consortia and centers of excellence. For example, the Airworthiness Assurance Center of Excellence (AA-COE) was established in September 1997 to conduct research in the areas of:

- Maintenance, inspection, and repair
- Crashworthiness
- Propulsions and fuel systems safety technologies
- Advanced materials

The AA-COE consists of 9 core members, 90 industry partners, 45 university affiliates, and 7 other partners, including other Government laboratories and state organizations. The COE provides matching funds, which solidify a significant COE-FAA partnership. Through this partnership, the Government, academic institutions, and industry leverage the resources available for aviation research.

Technology Transfer

Technology transfer occurs through a variety of mechanisms:

- Technical reports documenting research results.
- Conferences on a wide range of subjects designed to disseminate technical information.
- Technical organizations, such as the American Society on Testing and Materials (ASTM), Society of Automotive Engineers (SAE), and American Institute of Aeronautics and Astronautics (AIAA), that use study committees to ensure the transition of research results to standards, guidelines, etc.
- Hardware and software prototype demonstrations and technology workshops.
- The FAA Airworthiness Assurance Nondestructive Inspection Validation Center (AANC) demonstrations and validations of cost-effective aircraft inspection equipment and techniques to industry.

Long-Range View

The need for safety and safety-related research will continue indefinitely. With the emergence of new and advanced technologies, there will be an ongoing need to improve air transportation system safety. There will always be a need to understand the impact of new technology on operator performance. As air traffic continues to increase, and as aircraft continue to age, there will always be a need to address issues related to aging aircraft.

With new technology, new damage mechanisms may occur, introducing hazards that must be understood and addressed. Research in aircraft safety must be continued to understand the impact of changes in technology on current regulatory safety standards, certification procedures, and acceptable practices for demonstration of compliance mandates.

- Hardware and software prototype demonstrations and technology workshops
- The FAA Aging Aircraft Nondestructive Inspection Validation Center (AANC) demonstrations and validations of cost-effective aircraft inspection equipment and techniques to industry

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With new technology, new damage mechanisms may occur, introducing hazards that must be understood and addressed. Similarly, medical advances in diagnosis and treatment force a continuing examination of crew or passenger limitations in existing and future aircraft. Research in aircraft safety must be continued to understand the impact of changes in technology on current regulatory safety standards, certification procedures, and ac-

ceptable practices for demonstration of compliance mandates.

A06a Fire Research and Safety

GOALS:

Intended Outcomes: The FAA intends to improve system safety by developing technologies, procedures, test methods, and criteria for preventing accidents caused by in-flight fires and fuel tank explosions and eliminating burning cabin materials as a factor in post-crash fire survivability. The fire research and safety program focuses principally on:

- Long-term research to develop new interior materials that meet fire resistance criteria mandated in the Aviation Safety Research Act of 1988.
- Near-term improvements in aircraft fuel tank explosion protection, fire detection and suppression systems and interior materials fire test methods and criteria.

Agency Outputs: The FAA establishes rules for aircraft fire safety in terms of material selection, design criteria, and operational procedures. The agency also provides advisory material on methods of compliance with fire safety regulations and guidelines. The fire research and safety program is the major source of technical information used to develop this regulatory material. Additionally, the program provides industry with new safety products developed through long-term applied research. These products are typically embodied in new materials and formulations, new test methods, government-owned patents, reports, and journal publications.

Customer/Stakeholder Involvement: The FAA has broad industry and government participation in each aspect of the fire research and safety program.

- The Aircraft Safety Subcommittee of the FAA Research, Engineering and Development Advisory Committee has repeatedly endorsed the fire research and safety program and placed high priority on its activities.
- Long-term research in fire resistant materials is required by specific language in the Aviation Safety Research Act of 1988 and is directly supported by the aircraft industry and materials producers through university-based FAA research consortia.

- The FAA will soon create an Aviation Rule-making Advisory Committee (ARAC) on fuel tank inerting to recommend viable methods of fuel tank protection. This industry working group will impact related research undertaken by the FAA.
- The aircraft manufacturers and airlines have a need to evaluate halon replacement agents and improve interior material fire tests. Recognizing the FAA's unique capabilities in fire safety, the aviation industry actively participates in separate working groups headed by the FAA to develop approval standards for halon replacements and improved material fire tests. Foreign airworthiness authorities are active participants, as well, to ensure harmonization of outputs.
- The National Transportation Safety Board (NTSB) relies heavily on program personnel for on-site accident investigation such as the recent Swissair MD-11 and American Airlines MD-80 accidents.

Accomplishments: Results of fire research and safety were provided to FAA certification and inspection personnel for use in fire safety regulations and advisory material, approval of regulatory fire test procedures, and approval of aircraft fire protection installations. Recent program accomplishments include:

- Developed thermal acoustical insulation fire test criteria that were the basis for a major Notice of Planned Rulemaking (NPRM) planned for issuance in late 1999.
- Developed performance standards for gaseous halon replacement agents used in cargo compartment fire suppression systems and cabin hand-held extinguishers.
- Published technical report describing tests demonstrating the extreme fire hazards of chemical oxygen generators activated in proximity to combustible materials.
- Published technical report demonstrating the difficulties met by flight attendants attempting to extinguish fires in accessible cargo compartments.

- Published a technical report evaluating the effectiveness of cargo extinguishing systems against oxygen enhanced fires.
- Scaled-up benzoxazine chemistry through industrial consortium.
- Demonstrated a decorative panel with 60% reduction in heat release rate per FAR 25.853.
- Demonstrated optimized design, theory and operation of microscale heat release rate calorimeter (Patent awarded).
- Published four journal articles, one technical report and 10 conference proceedings on heat release rate of fire resistant materials.
- Formed partnership with Boeing, Schneller Inc., Ciba Specialty Chemicals, and the University of Massachusetts to scale-up and evaluate chloral polymers for aircraft interior applications.

In addition, approximately two dozen reports and published papers are generated yearly from the in-house activity. Fire test laboratories are used annually to train FAA certification engineers, and program personnel participate in approximately three major accident investigations yearly at the request of the NTSB. The FAA operates the most extensive aircraft fire test facilities in the world.

R&D Partnerships: The FAA sponsors an international halon replacement working group. This group collaborates in research and development leading to alternate agent selection for aircraft applications as well as test methods and criteria. The FAA also sponsors an international aircraft materials fire test working group. This group strives to improve material fire tests standardization, such as engaging in round robin testing to ensure that the lab-to-lab variation in results is acceptably small. The FAA organized an inter-agency working group on fire and materials to provide a vehicle for technology exchange among U.S. Government agencies and to prevent unwarranted duplication of work. The FAA has inter-agency agreements with the U.S. Air Force and the National Institute of Standards and Technology for common interest research. The agency has a memorandum of cooperation with the British Civil Aviation Administration (CAA) for a variety of fire safety research efforts and separate

letters of cooperation with Canadian, Japanese, and European aviation authorities. The fire research and safety program also has grant programs with many educational institutes. Several Fortune 100 companies share costs of developing new fire resistant materials at university-based FAA research consortia.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Fire Resistant Materials

- Commercialized FAA microscale heat release rate calorimeter.
- Made available user-friendly computer code for predicting material flammability.
- Demonstrated molded thermoplastic for cabin parts with 50% reduction in heat release rate.

Fire Detection and Suppression

- Developed a performance standard for gaseous halon replacement agents in engine fire extinguishing systems.
- Developed smoke/fire simulants for use in cargo detector approval testing.
- Completed full-scale effectiveness testing of cargo compartment water mist system.
- Determined cost and evaluated performance of a prototype airport ground-based fuel tank inerting system.
- Initiated development of an airborne fuel tank inerting system.

Fire Safety Design

- Completed laboratory round robin studies of new fire test criteria developed for thermal acoustical insulation.
- Evaluated explosive hazards related to fuel tank heating/cooling and localized hot surfaces.
- Designed and constructed a full-scale fuselage test article for characterizing fire hazards in new double-decked Very Large Transport Aircraft (VLTA).
- Publish Upgraded Material Fire Test Handbook.

2000 FAA NATIONAL AVIATION RESEARCH PLAN

A06a - Fire Research and Safety Product and Activities	FY 2001 Request (\$000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
<i>061-110 Fire Research and Safety</i>							
Fire Safety Design	\$727						
Completed Laboratory Round Robin Studies	◆						
Designed and Constructed a Full-Scale Fuselage Test Article	◆						
Publish Upgraded Material Fire Test Handbook	◆					◇	
Initiate Study of Aircraft Hull Losses and Fatalities Caused by Oxygen System Malfunction or Damage			◇				
Draft Oxygen Systems Safety Advisory Circular (AC)						◇	
Characterize Cabin and Fuselage Fires in Very Large Transport Aircraft (VLTA)			◇				
Define VLTA Fire Protection Methodology							◇
Fire Resistant Materials	\$1,005						
Demonstrated Thermoplastic for Molded Parts with 50% Reduction in Heat Release Rate	◆						
Commercialized FAA Microscale Heat Release Rate Calimeter	◆						
Scale-Up Chloral Polymers for Evaluation			◇				
Demonstrate Seat Cushion with 50% Reduction in Heat Release Rate				◇			
Link Heat Release Data to National Institute of Standards and Technology (NIST)			◇				
Demonstrate Cost Effective Low Heat Release Materials						◇	
Fire Detection and Suppression	\$650						
Completed Cargo Compartment Water Mist Fire Suppression System Evaluation	◆						
Determined Fuel Tank Explosion Hazards	◆						
Determined Cost/Performance of Prototype Airport Ground-Based Inerting System	◆						
Design and Install an Airborne Fuel tank Inerting System			◇				
Flight Test Fuel Tank Inerting System				◇			
Assess Oxygen/Nitrogen Separation Membrane Technology				◇			
Developed a Performance Standard for Gaseous Halon Replacement Agents	◆						
Complete Full-Scale Test Evaluation of Solid Propellant Gas Generator Technology			◇				
Revise Draft Advisory Circular for Smoke/Fire Detection			◇				
Develop Criteria for Approval of Reduced False-Alarm Smoke/Fire Detector Designs				◇			
Personnel and Other Costs	\$3,069						
Total Budget Authority	\$5,451	\$4,750	\$5,451	\$5,635	\$5,845	\$6,081	\$6,342

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority (\$ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	2,963	3,377	2,098	1,292	2,382
Personnel Costs	3,345	3,001	2,315	3,116	2,856
Other Costs	685	615	337	342	213
Total	6,993	6,993	4,750	4,750	5,451

KEY FY 2001 PRODUCTS AND MILESTONES:*Fire Resistant Materials*

- Scale-up chloral polymers for evaluation in production panels and molded parts.
- Make available computational models of polymer combustion.
- Link heat release database to National Institute of Standards and Technology fire web site.
- Fire Detection and Suppression
- Draft a revised Advisory Circular (AC) for approval testing of cargo smoke detectors.
- Design, fabricate and install a fuel tank inerting system on a flight test aircraft.
- Determined Fuel Tank Explosive Hazards.

Fire Safety Design

- Characterize cabin and fuselage fires in VLTA under full-scale fire tests conditions.
- Initiate study of aircraft hull losses and fatalities caused by oxygen system malfunction or damage.

FY 2001 PROGRAM REQUEST:

In FY 2001, long range research on ultra-fire resistant aircraft interior materials will focus on synthesizing and evaluating the heat release rate of an entire class of promising polymers based on chlorobisphenol monomer. Near term fire safety improvements will focus on fuel tank explosion protection, fire management, and new double-decked transport aircraft. Utilizing prior year test results, an airborne fuel tank inerting system will be designed and fabricated in FY 2001 for flight testing in FY 2002. A multi-year effort to develop standardized testing procedures for the approval of cargo detectors will culminate in a revised Advisory Circular. To support possible new fire safety standards for double-decked VLTA, the characteristics of cabin and fuselage fires will be measured under full-scale test conditions. Finally, work will commence related to fixed oxygen system fire safety by initiating a study to document and analyze past aircraft fire fatalities and hull losses caused by oxygen system failures.

A06b Advanced Materials/Structural Safety

GOALS:

Intended Outcomes: The FAA intends to ensure the safety of U.S. and foreign-made civil aircraft constructed of advanced materials as well as to improve passenger survival in the event of an accident. The study of advanced materials focuses on the following technical areas:

- Standardized analysis and test methods for worldwide harmonization.
- Better understanding of effects of repeated loads, damage, and joint configurations on remaining strength and life of composite aircraft structure.
- Reliability methods, as they apply to the design of composite aircraft components, and criteria for acceptable risk.

The study of structural safety focuses on the following technical areas:

- Enhanced occupant survivability and reduced personal injury in the event of an accident.
- Improved crash characteristics of aircraft structures, cabin interiors, auxiliary fuel tank systems, and occupant seat/restraint systems.
- Improved analytical and modeling capabilities to develop understanding of aircraft crash events to lead to more efficient certification.

Agency Outputs: The FAA establishes rules for aircraft certification and operation and publishes Advisory Circulars (AC) to provide acceptable means of achieving compliance with those rules. While the rules are the same for composite or metal structure, the means of compliance reflect behavioral differences in the structural materials. AC 20-107A, "Composite Structure" has been published, but advances in technologies and materials lead to periodic updates and expansion of the AC. Technical information is disseminated to regulatory personnel through technical reports, handbooks, and guidance by the FAA National Resource Specialist. The goal is to develop pertinent data, so that the regulatory processes keep pace with industry advances, including state-of-the-art test and evaluation for state-of-the-art technology and design. The advanced materials/structural safety program provides support in rulemaking and the development of guidance material for industry compliance. In structural

safety, the FAA revises or updates Federal Aviation Regulations to accommodate new information for overhead stowage bins, auxiliary fuel tanks, and seat/restraint systems.

Customer/Stakeholder Involvement: The FAA has demonstrated the need for the advanced materials/ structural safety program through consensus building activities including:

- The Aviation Rulemaking Advisory Committee (ARAC) is a FAA/industry forum established to ensure that agency rulemaking is effective in achieving intended results. ARAC is also effective in identifying requirements and priorities for supporting R&D activities.
- The Challenge 2000 report concludes that the FAA should enhance its already effective program of gathering data and improving the certification of composite structures.
- A recent National Research Council report highlights the needs related to advanced materials and urges the FAA to step up advanced materials research for aircraft community benefits.
- The 1994 DOT Strategic Plan established Goal 3.3, "support the use of advanced materials in manufacturing and constructing transportation facilities and equipment."
- The advanced materials/structural safety program is responsive to Public Law 100-591, Aviation Safety Research Act of 1988, and House of Representatives Report 100-894, to develop technologies, to conduct data analysis for current aircraft, and to anticipate problems of future aircraft.

Accomplishments: Results of this program are provided to aircraft manufacturers, maintainers, and operators in the form of technical reports, handbooks, ACs, and guidance in the process of certification.

In the advanced materials area, the program has updated or issued two ACs and four handbooks, published more than 50 technical reports, articles, and papers, and has cosponsored three technical conferences with attendance of approximately 1,200 experts. A three volume report on test methods for composites was disseminated to industry and government to provide an authoritative

compendium on state-of-the-art composites testing with recommendations for usage and identified gaps. An alternative method of compliance to demonstrate repeated load life was developed and now significantly reduces fatigue testing time to ensure required service life. This method has been used successfully in the certification process of many aircraft components (recent example, the General Electric 90 fan blades) and has been adopted as a worldwide practice.

In the structural safety area, six reports on in-house commuter crash testing, as well as reports on aircraft ditching and aircraft flotation, have been widely disseminated. Rulemaking has been proposed for commuter seat/restraint systems. Also, in-service overhead stowage bins have been made more resilient to crash impact. A workshop on a crash impact modeling code developed by the FAA was held for certification engineers and industry participants.

R&D Partnerships: In the advanced materials area, the FAA coordinates with NASA to leverage research expenditures. The FAA concentrates on safety and certification issues, including testing, while NASA has the lead in analysis and design issues. Currently, the FAA supports NASA's efforts to develop a composite property database for General Aviation (GA) aircraft under the NASA Advanced GA Transport Experiments (AGATE)/Integrated Design and Manufacturing (IDM) Program. The FAA has also initiated a partnership with the Rotorcraft Industry Technology Association (RITA) to share in rotorcraft composite materials research.

The FAA cosponsors, with the U.S. Army, MIL-HDBK-17, a primary and authoritative source for statistically based characterization data of current and emerging composite materials. This international reference reflects the best available data and technology for testing and analysis, and includes data development and usage guidelines. The handbook is used by FAA officials as a primary supporting document in structural substantiation in the certification process. On recommendations by the ARAC committee, material data contained in this handbook will be acceptable for use in the certification process. In the structural safety area, there are agreements for cooperative programs with the National Highway

Traffic Safety Administration (NHTSA), with the U.S. Army and Navy, and with NASA Langley Research Center.

There has been coordination with the French and Italian Governments through memoranda of cooperation and an exchange of personnel in the crash testing area. A cooperative research program in the development of crash modeling software tools is underway with the United Kingdom. The program has also worked closely with Wichita State University to develop crash dynamic models and experimental energy absorbing seats.

The structural safety area has established working relationships with airframe manufacturers such as Boeing and Raytheon and with manufacturers of overhead bins and auxiliary fuel tanks. The advanced materials and structural safety areas are benefiting from a close working relationship with the Airworthiness Assurance Center of Excellence. The research performed under this program is leveraged by the monetary and intellectual contributions of its core universities.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Advanced Materials

- Completed research on damage accumulation in composites due to repeated loads. This aids in developing certification criteria for composite structural components.
- Established methodology to predict delamination initiation and growth at critical details in composite structures.
- Provided database for support to AGATE/IDM on effects of bond thickness on structural performance of small composite aircraft.
- Developed new thermal analysis model for composite aircraft.
- Initiated new start to address certification issues of composite materials pertaining to rotorcraft.

Structural Safety

- Completed vertical drop test of a B737 fuselage section with overhead bins to determine their behavior under a survivable crash scenario.

2000 FAA NATIONAL AVIATION RESEARCH PLAN

A06b - Advanced Materials/Structural Safety Product and Activities	FY 2001 Request (\$000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
<i>062-111 Advanced Materials Structures</i>							
Advanced Materials	\$978						
Established Methodology to Predict Delamination Initiation		◆					
Established Data Base on Effects of Bond Thickness		◆					
Generate Data Base for Durability of Textile Forms			◇				
Establish Criteria for Damage Tolerance of Sandwich Structures			◇				
Establish Rules for Replacing Metal Rotorcraft Parts with Composites			◇				
Establish Guidelines for Probabilistic Design Certification				◇			
Develop Data Base on Verified Design Practice for Adhesive Joints				◇			
Develop Data Base on Damage Tolerance of Sandwich Structure					◇		
Develop Durability and Damage Tolerance Data for Rotorcraft					◇		
Identify Data for Certification of Materials at Elevated Temperatures						◇	
Develop Certification Methodology for New Materials and Forms						◇	
Develop Certification Methodology for High Cycle Fatigue							◇
<i>062-110 Structural Safety</i>							
Structural Safety	\$822						
Completed Vertical Drop Test of B737 Fuselage Section with Stowage Bins		◆					
Completed Aircraft Crash Modeling Tool for Accident Investigators		◆					
Establish Guidelines for Conducting Head Injury Criteria (HIC) Component Testing			◇				
Complete Assessment of the Crash Resistance of Transport Fuel Systems			◇				
Complete Rotorcraft Ditching Research in Conjunction with the Navy			◇				
Publish Data on Crash Resistance of Transport Aircraft Stowage Bins			◇				
Develop Analytical Capability to Model Aircraft Crash Events				◇			
Identify Transport Ditching Requirements				◇			
Define Rotorcraft Crash Pulse					◇		
Define New Occupant Injury Criteria					◇		
Establish Crash Test Data Base						◇	
Validate Water Impact Model						◇	
Develop Occupant Protection Criteria for Side Seating							◇
Personnel and Other Costs	\$997						
Total Budget Authority	\$2,797	\$2,338	\$2,797	\$2,866	\$2,948	\$3,046	\$3,162

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority (\$ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	1,249	2,059	809	1,089	1,800
Personnel Costs	1,507	835	803	1,109	937
Other Costs	309	171	122	140	60
Total	3,065	3,065	1,734	2,338	2,797

- Completed aircraft crash modeling tool for accident investigators.
- Initiated research on the effect of side facing seating on occupant protection criteria and restraint systems.
- Complete ditching research in conjunction with the Navy.

KEY FY 2001 PRODUCTS AND MILESTONES:

Advanced Materials

- Generate a database for durability of textile forms and stitching as manufactured by resin transfer molding.
- Establish criteria to assure damage tolerance of composite sandwich structures for small aircraft and rotorcraft.

Structural Safety

- Complete assessment of the crash resistance of current rotorcraft, commuter, and transport fuel systems.
- Establish guidelines for conducting Head Injury Criteria (HIC) component testing to supplement full scale testing.
- Publish data on behavior of transport aircraft overhead storage bins in a severe but survivable crash.

FY 2001 PROGRAM REQUEST:

In FY 2001, the program continues to focus on the areas listed at the beginning of the GOALS section above. Specific areas are damage tolerance of sandwich structures applicable to current and future aircraft fuselages, durability of textiles, and developing a database on effects of bond thickness on structural performance of small bonded composite aircraft. In addition, work will continue to develop data applicable to rotorcraft. Within the structural safety area, a unified analytical modeling capability will be under development in order to reduce costly testing. The models will include the response of seats, restraint systems, seat attachments, and airframes under dynamic crash conditions. Other areas of research to be continued are crash resistance of fuel systems, determination of loads in rotorcraft ditching, and development of component tester for HIC compliance. A drop test of a representative rotorcraft to determine dynamic loads will also be conducted in future years.

A06c Propulsion and Fuel Systems

GOALS:

Intended Outcomes: The FAA intends to improve system safety by enhancing the airworthiness, reliability, and performance of civil turbine and piston engines, their propellers, fuels, and fuel management systems. The major outcomes from this program include:

- Continued reliability and safety of general aviation operations by providing a safe transition to a new high octane unleaded aviation gasoline.
- A reduction in the number of intrinsic turbine rotor failures by improved and standardized design and life management procedures.
- Improved melt processes for premium quality titanium alloys used for turbine rotor components.
- Improved manufacturing and quality practices to eliminate manufacturing induced anomalies in turbine rotor components.
- Reduced turbine engine failure/downtime and improved maintenance efficiency through advanced monitoring/diagnostic hardware and software.
- Minimized probability of in-flight fuel tank explosions.
- Continued reliability and safe use of Jet A fuel containing red dye contamination.

Agency Outputs: The FAA maintains the airworthiness of aircraft engines, fuels, and airframe fuel management systems by issuing certification and advisory standards, and by supporting technical society specifications and recommended practices. The FAA also publishes technical information in various forms in the public domain. Technology may also be provided to the industry through hardware and software prototype demonstrations and technology workshops or various training medium. This research program provides the resources and oversight to deliver the necessary propulsion, fuel, and fuel transfer system technology in support of these agency outputs.

Customer/Stakeholder Involvement:

- The FAA collaborates with the engine industry to identify and implement cost effective

safety improvements that address incidents and accidents caused by in-service engine failures. This collaboration was initiated by the FAA Titanium Rotating Components Review Team. This team advises on the adequacy of industry standards and procedures to ensure the safety of the titanium alloy high energy rotating components of turbine engines. Industry participation is through working committees under the Aerospace Industries Association (AIA), including the Materials and Structures Committee, Rotor Integrity Subcommittee, Rotor Manufacturing Subcommittee and the Jet Engine Titanium Quality Committee.

- The AIA committees identify potential improvements in manufacturing process control, manufacturing and in-service inspection, and design and life management of failure critical rotating engine parts. These improvements are the basis for identifying specific R&D already underway or planned for this program.
- The FAA participates and provides leadership in testing capability for the Coordinating Research Council (CRC) Unleaded Aviation Gasoline Development Group. This group was formed in February 1995 to oversee research and testing for the development of the next generation of high octane unleaded aviation gasoline. EPA regulations and the Clean Air Act of 1990 mandate removal of lead from all gasoline. The critical need for the development of this fuel is reflected by the list of participants on the CRC group. Active participants and members of this group include: most major oil companies (U.S. and worldwide); general aviation airframe and engine manufacturers; general aviation user groups such as the Aircraft Owners and Pilots Association (AOPA), Experimental Aircraft Association (EAA), and General Aviation Manufacturers Association (GAMA); the research sponsor, the FAA New England Region Engine and Propeller Directorate; and the FAA Small Airplane Directorate in Central Region.
- The FAA sponsored Technical Oversight Group On Aging Aircraft (TOGAA) reviews

technical aspects of the airworthiness assurance R&D activities. TOGAA has provided feedback on the progress of the turbine engine program over the last three years.

- The Subcommittee on Aircraft Safety of the FAA Research, Engineering and Development Advisory Committee was briefed on the propulsion program, an initiative which the subcommittee strongly supports.
- The FAA/industry initiative on turbine engine rotor integrity research in this program addresses National Transportation Safety Board (NTSB) recommendations A-90-89 and A-90-90.
- The program addresses recommendations of the FAA Titanium Rotating Components Review Team Report, which was presented to industry in a public meeting held in May of 1991.
- The program supports recommendations by the Aviation Rulemaking Advisory Committee (ARAC) Fuel Tank Harmonization Working Group.

The Aerospace Industries Association convened an ad hoc group to study the effects of red dye contamination of Jet A fuel and to identify solutions to this problem. This effort has resulted in a program funded by the FAA, Defense Energy Support Center, Internal Revenue Service (IRS), Air Transport Association, and engine and airframe manufacturers. Additional funding from the oil refiners may be forthcoming.

Accomplishments: Results of the propulsion and fuels research program provided to engine and aircraft regulatory and industry stakeholders:

- Drafted an advisory circular on the correlation, operation, design, and modification of turbofan/jet engine test cells, which provide guidance on the testing of aircraft engines.
- Completed a training video production entitled; "Aircraft Turbine Engine Test Cell Correlation."
- Hosted and sponsored four annual joint FAA/Air Force public workshops with published proceedings on the application of probabilistic design methodology to gas turbine rotating components.

- Demonstrated integrated probabilistic rotor design and life management code (DARWIN version 3.2) for titanium alloys to provide commercial aircraft turbine engine manufacturers a tool to augment their current "safe life" management philosophy approach.
- Conducted DARWIN Code version 3.2 FAA/Industry training workshop.
- Demonstrated and delivered the defect deformation micro code for analysis of titanium alloy defects during the turbine disk forging process.
- Determined the fleet octane requirement to be the single most critical parameter for development of high octane unleaded aviation gasoline.
- Completed validation of ground based procedures for determining octane requirements to be used in the development of a new high octane unleaded aviation gasoline.
- Participated in establishing matrix components to be used in developing candidate fuel formulations.
- Initiated engine tests on an industry-supplied fuel formulation.
- Completed report on engine octane requirements.
- Determined and defined detonation detection procedures for proposed ASTM method to test unleaded replacement fuel(s).
- Issued final determination of fleet octane requirements for unleaded replacement in high fuel performance piston engines to be greater than 100 octane.
- Completed draft final report on in service Jet A fuel sample analysis volatility survey.

R&D Partnerships:

A cooperative grant was awarded to the Southwest Research Institute, which has teamed with major engine manufacturers Pratt and Whitney, General Electric, Honeywell (Allied-Signal), and Rolls Royce-Allison. This work develops probabilistic-based turbine rotor material design and life management tools for improved rotor integrity. This work is closely coordinated with the U.S. Air Force Wright Laboratory, which conducts complementary

research, and with ongoing research activities of the FAA Engine Titanium Consortium sponsored under budget item A06e, Aging Aircraft. The FAA transfers the completed probabilistic engine design code versions for use by the industry via training workshops.

- The partnership exhibited by the CRC Unleaded Aviation Gasoline Development Group provides an arena to conduct research that is unprecedented in the aviation gasoline industry. The proprietary and competitive forces inhibiting progress, in the high octane aviation gasoline development, have been set aside. This allows the transfer of technology to and from government and industry to benefit all participants. Industry participants include Texaco, Exxon, Phillips Petroleum, Chevron, British Petroleum, Cessna, Raytheon (Beech), Teledyne Continental, and Textron Lycoming.
- A FAA contract with the Southwest Research Institute will determine an acceptable level of fuel dye contamination, which allows continuous safe turbine engine operation. The following organizations contribute funding to this effort: the FAA, Defense Energy Support Center, IRS, Air Transport Association, American Petroleum Institute, General Electric, Pratt & Whitney, Rolls Royce, Honeywell (AlliedSignal) and Boeing.
- The program is benefiting from a close working relationship with the Airworthiness Assurance Center of Excellence. The research performed under this program is leveraged by the monetary and intellectual contributions of its core universities.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Completed draft report on the results of titanium melting enhancements.
- Continued laboratory characterization of industry supplied preliminary candidate fuels.
- Continued engine ground testing of industry supplied preliminary candidate unleaded fuels.
- Began characterization and testing of industry supplied candidate fuels using FAA engine ground test facilities.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Commercialize the DARWIN rotor design and life management code.
- Complete validation of the DARWIN rotor design and life management code.
- Complete spin pit tests of disks that contain hard alpha defects to validate the FLIGHT_LIFE fracture mechanics module in DARWIN.
- Complete vacuum fatigue crack growth tests on nickel alloys.
- Publish report that defines an acceptable concentration of red dye contamination in Jet A fuel for continuous engine operation.
- Commence flight tests on industry supplied candidate unleaded fuels.

FY 2001 PROGRAM REQUEST:

In FY 2001, the program continues development of a probabilistically based turbine engine rotor design code with damage tolerance assessment. This code will be a life and risk management tool to augment the current "safe life" design approach for integration into engine manufacturer rotor design procedures. The application of this tool, as a FAA approved design certification standard, is intended to improve turbine rotor structural integrity while reducing the risk of failure.

The program also continues research on industry provided lead free fuel formulation candidates to replace the low lead aviation gasoline (ASTM D910 100LL) currently in use. These tests evaluate new fuel formulation effects on engine detonation, material compatibility, volatility, engine performance, storage stability, water reaction, emissions, fuel consumption and engine durability. In FY2001 fuel tests using the FAA flight test aircraft will begin. All parameters impact on safe engine operation and all data supports eventual certification of a replacement fuel.

The program continues to develop rotor disk alloy material melt processes to establish commercial manufacturing standards that will eliminate metallurgical defects to produce premium quality, rotor grade alloy materials. Commercial aircraft accident history has shown that the presence of these defects in rotor disks have been the initiat-

2000 FAA NATIONAL AVIATION RESEARCH PLAN

A06c - Propulsion and Fuel Systems Product and Activities	FY 2001 Request (\$000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
<i>063-110 Propulsion and Fuel Systems Research</i>							
Turbine Engine Research	\$3,150						
Validate the Probabilistic Rotor Design and Life Management Code (DARWIN)			◇				
Commercialize Darwin Code			◇				
Demonstrate Probabilistic Integration Design Code – Surface Flaws				◇			
Deliver Probabilistic Rotor Design Code – Nickel Alloys					◇		
Reported on Results of Titanium Melting Enhancements		◆					
Verify Hearth Melt Process Models				◇			
Demonstrate the On-line Monitoring for Alloy Composition Control in a Commercial Electron Beam Melt Furnace						◇	
Develop Equations for Finite Element Modeling of Cold Dwell Fatigue					◇		
Develop Computer Model for Cold Dwell Fatigue Damage Evolution and Failure in Titanium							◇
Unleaded Fuels and Fuel System Safety Research	\$862						
Continued Laboratory Characterization of Industry Supplied Candidate Fuels		◆					
Continued Engine Ground Testing of Industry Supplied Candidate Unleaded Fuels		◆					
Complete Determination of Acceptable Concentration of Red Dye Contamination in Jet A Fuel for Continuous Engine Operation			◇				
Begin Flight Tests on Industry Supplied Candidate Fuels			◇				
Complete Draft Specification for High Octane Unleaded Aviation Gasoline				◇			
Begin Fleet Evaluation of Candidate Unleaded Aviation Gasoline				◇			
Personnel and Other Costs	\$1,188						
Total Budget Authority	\$5,200	\$3,126	\$5,200	\$5,296	\$5,423	\$5,580	\$5,770

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority (\$ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	1,566	3,643	1,761	1,754	4,012
Personnel Costs	1,522	1,126	932	1,230	1,114
Other Costs	312	231	138	142	74
Total	3,400	5,000	2,831	3,126	5,200

ing cause of uncontained rotor failures. These failures are a major contributor associated with the engine failure fatal accident rate.

In FY 2001, the program will initiate R&D support of the AIA Rotor Manufacturing Subcommittee to develop advanced manufacturing technologies. The purpose of this activity is to qualify and control the final surface

manufacturing processes that could have an impact on rotor disk fatigue life.

The FY 2001 program continues research to establish an improved understanding of the metallurgical factors that shorten fatigue life in titanium rotor disk alloys. The microstructure-based modeling capability developed by this activity will enable more accurate prediction of the risk of serious engine caused accidents.

A06d Flight Safety/Atmospheric Hazards Research

GOALS:

Intended Outcomes: The FAA intends to improve aircraft safety by developing technologies, technical information, procedures, and practices. These measures help ensure safe operation of the civil fleet in icing conditions and in the electromagnetic environment, and address safety issues pertaining to software, digital flight controls and avionics systems.

In the area of aircraft icing, the program focuses on establishing operating rules and procedures for deicing and anti-icing to ensure a clean aircraft at takeoff. It also focuses on developing technology to determine the existence of frozen contamination and the failure of anti-icing fluids on critical aircraft surfaces. It addresses characterization of the atmospheric icing environment by collecting and analyzing supercooled cloud and precipitation data. It also develops technology (ice protection and detection), certification requirements, and advisory material to ensure that aircraft meet performance, stability, and control safety standards during or after in-flight operation in icing conditions.

The electromagnetic hazards to aircraft systems program focuses on protecting aircraft electrical and electronic systems against the effects of lightning and High Intensity Radiated Fields (HIRF). HIRF effects may come from airborne, shipborne and ground based emitters, and from portable electronic devices, i.e., tape players, laptop computers, cellular phones, etc.

The software and digital systems safety program addresses aircraft safety and certification issues. These issues involve the use of emerging, highly complex, software based digital flight controls and avionics systems in flight essential and flight critical applications.

Agency Outputs: The FAA establishes rules for aircraft operation in icing conditions and the electromagnetic environment, software, digital flight controls, avionics systems, and electromagnetic hazards. It also publishes advisory circulars (AC) to outline acceptable means for meeting the rules and disseminates various forms of technical information to agency certification and airworthiness specialists, agency

inspectors, and to the aircraft and avionics industry. The program fosters development of promising technologies such as sensors, to detect frozen contamination, and anti-icing fluid failure. The aircraft icing project joins with the Society of Automotive Engineers (SAE) in annual updates to aircraft holdover time guidelines. These provide time estimates of the effectiveness of de/anti-icing fluids.

Customer/Stakeholder Involvement: The program directly supports the FAA Strategic Plan Mission Goal for Safety: By 2007, reduce U.S. aviation fatal accident rates by 80 percent from 1996 levels. The program directly supports the Safety Strategic Focus Area of Accident Prevention. It does this through enhancements to aircraft certification, inspection, and maintenance relative to atmospheric hazards and advanced software and digital systems. It also directly supports Challenge 2000 through research and increased awareness in the area of software and standardization efforts among the certification directorates. In addition, it supports the free flight initiative, addressing highly integrated avionics and ground based systems safety and certification issues, using very complex software. A key supporter is the Aviation Rulemaking Advisory Committee (ARAC) Electromagnetic Effects Harmonization Working Group (EEHWG).

The ARAC Flight Test Harmonization Working Group (FTHWG) addresses performance and handling requirements standardization, and guidance material for operation in icing conditions. The ARAC Ice Protection Harmonization Working Group (IPHWG) addresses definition of an icing environment that includes Supercooled Large Droplets (SLD) and means, such as ice detectors, to discriminate between conditions within and outside the certification envelope and to warn flightcrews of ice accumulation on critical surfaces. An SAE committee also address aircraft lightning protection (AE-2). This committee develops ACs, test standards, and related users manuals to improve flight safety. The FAA provides leadership to the SAE G-12 Aircraft Ground Deicing Committee. This committee addresses holdover time guideline updates, standards establishment for de/anti-icing

methodologies and fluids, and sensor criteria to determine the existence of frozen contamination. It also addresses the failure of anti-icing fluids on critical aircraft surfaces.

Accomplishments: The program provided aircraft icing regulatory guidance and operating procedures to aircraft manufacturers and operators. This consisted of technical reports, handbooks, information bulletins, ACs and rules. Since 1992, the program has updated or issued two ACs, five technical bulletins, and the Aircraft Icing Handbook (twice), and it has published more than 35 technical reports or papers, including reports on ice phobic technologies. It has held international conferences on aircraft ground deicing (more than 600 participants from more than 10 countries), on aircraft in-flight icing (more than 400 participants from 20 countries), and on mixed-phase and glaciated icing conditions (more than 50 participants from five countries). It has also issued holdover time guidelines for deicing and anti-icing fluids.

In the area of software and digital systems safety, the program completed a software mutation study to assess the structural coverage testing requirements for avionics software. The program completed the third Streamlining Software Aspects of Certification (SSAC) Workshop in which numerous avionics software development and approval processes were identified for improvement. A feasibility study for an In-flight Advisor for civil aircraft was also published.

In the electromagnetic hazards area, the program published two reports measuring the closest approach distance between aircraft and emitters. The program also published a HIRF Risk Analysis Report used in support of a notice of proposed rulemaking. An update to the FAA Research and Development Electromagnetic Database (FRED 2.0) containing lightning strike data and waveforms was published and distributed. The update included C-160 Aircraft lightning strike data.

R&D Partnerships: The program has established many cooperative relationships, including the following:

- ARAC, EEHWG international certification authority/industry forum – HIRF environment, User's Guide for AC 20-1317.
- SAE-AE-2 Lightning Protection of Aircraft, Lightning Environment, Waveforms and Testing Standard, Aircraft Zoning Standard, and User's Manual for AC 20-136.
- RTCA Special Committee-135, "Environmental Conditions and Test Procedures for Airborne Equipment."
- RTCA Special Committee-180, "Design Assurance Guidance for Airborne Electronic Hardware."
- RTCA Special Committee-182, "A Minimum Operational Performance Standard (MOPS) for an Avionics Computer Resource (ACR)."
- RTCA Special Committee-190, "Software Considerations in Airborne Systems and Equipment Certification."
- Multiyear FAA/NASA interagency agreement with Langley Research Center to cooperate in the assessment of software based digital flight controls and avionics systems and electromagnetic hazards research.
- Multiyear interagency agreement with Naval Air Warfare Center Aircraft Division to assess the HIRF environment for aircraft.
- Letter of agreement to leverage HIRF certification research with Sandia Corporation, Army Directorate for Applied Technology, Test and Simulation, and ORION International Technologies, Incorporated.
- Certification Authorities Software Team (CAST) consisting of avionics software systems certification authorities from U.S., Europe and Canada.
- Cooperative efforts on aircraft icing activities with the NASA Lewis Research Center.
- Aircraft icing has more than six grants and agreements in place with academia and other government agencies to "leverage" interests and capabilities.
- An international agreement exists with Transport Canada on research on aircraft ground deicing issues.

- An international memorandum of cooperation exists with the Atmospheric Environment Service of Canada for research on in-flight icing conditions.

An Interagency agreement with the Air Force for development of a new icing tanker for military and commercial use.

ARAC IPHWG directly supported with data on and analysis of SLD conditions in the atmosphere.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Aircraft Icing

- Evaluated time effectiveness of recently developed new and environmentally friendly deicing/anti-icing fluids, including assessment of effect of removal of triazoles.
- Completed report on glycol temperature buffer reduction investigation.
- Completed report on fabrication of active aircraft mounted wide area ice detector prototype system.
- Published report on consolidation of SLD data at flight altitudes.
- Published report on artificial ice shapes used in certification.

Software and Digital Systems Safety

- Published Report on Avionics Software Mutation approach to structural coverage requirements in RTCA DO-178B.
- Published report on COTS software and hardware alternative certification methods.
- Published plan for Complex Hardware Case Study based on RTCA SC-180, DO-TBD document.

Electromagnetic Hazards to Aircraft Systems

- Published HIRF User's Guide for AC 20-1317.
- Published Lightning User's Manual for AC 20-136.
- Initiated a lightning strike characterization study for definition of aircraft lightning environment.

- Published In-service lightning strike data and analysis report.

KEY FY 2001 PRODUCTS AND MILESTONES:

Aircraft Icing

- Evaluate time effectiveness and aerodynamic performance of environmentally friendly and other modern fluids.
- Complete investigation of procedures and methods for laboratory determination of fluid holdover times.
- Publish report on improvement of icing simulation methods.
- Publish report on documentation and quantitative characterization of ice shape and roughness.
- Publish report on aerodynamic effects of residual and intercycle ice.

Software and Digital Systems Safety

- Publish report on certification considerations for COTS hardware and software.

Electromagnetic Hazards to Aircraft Systems

- Publish report on single event effects and upset.
- Publish update report on analysis of commercial in-service lightning data.
- Publish report on characterization of aircraft lightning environment.

FY 2001 PROGRAM REQUEST:

Aircraft Icing

- Continue to collect and assess the global atmospheric icing environment data, including steps to acquire data from operational aircraft.
- Determine acceptance criteria for icing tankers, tunnels, and analytical icing computer codes.

Software and Digital Systems Safety

- Continue research relative to emerging flight safety and certification issues identified by CAST and RTCA SC-190 efforts.

2000 FAA NATIONAL AVIATION RESEARCH PLAN

Electromagnetic Hazards to Aircraft Systems
Continue research relative to lightning protection.
HIRF and Lightning Safety/Atmospheric Hazards Research

ity, in-service lightning data, single event effects/upset and continued integrity research.

Product and Activities	FY 2001 Request (\$000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
064-110 Flight Safety							
Software and Digital Systems Safety	\$168						
Published Report on Software Structural Coverage Using Mutation Testing		◆					
Publish Report on Certification Considerations for COTS Software & Hardware			◇				
Publish Report on Certification Acceptance Criteria for Software Service History				◇			
Publish Case Study Concerning Certification Techniques for Complex Electronic Hardware				◇			
Publish Report on Acceptance Criteria for Software Reuse					◇		
Publish Report on Certification Considerations for Object Oriented Technology						◇	
064-111 Atmospheric Hazards							
Aircraft Icing	\$1,691						
Continue Collecting Atmospheric Icing Data Aloft		◆	◇	◇	◇		
Evaluate Time of Effectiveness and Aerodynamic Performance of Environmentally Friendly Modern Fluids		◆	◇	◇	◇		
Reported on Fabrication of Active Aircraft Mounted Wide Area Ice Detector Prototype System		◆					
Reported on Consolidation of Supercooled Large Droplet (SLD) Data at Flight Altitudes		◆					
Reported on Glycol Temperature Buffer Reduction Investigation		◆					
Publish Report on Documentation & Quantitative Characterization			◇				
Report on Acquisition of Atmospheric Icing Data from Operational Aircraft			◇				
Report on Global Atmospheric Icing Environment						◇	
Publish Fluid Failure and Holdover Times Procedures for Manufacturers						◇	
Report on New Ice Phobic Technologies							◇
Electromagnetic Test and Analysis	\$807						
Published High Intensity Radiated Fields (HIRF) User's Guide		◆					
Published Lightning User's Manual for Advisory Circular (AC) 20-136		◆					
Publish Report on Single Event Effects and Upset			◇				
Publish Update Report on Analysis of Commercial In-Service Lightning Database			◇				
Publish Report on Characterization of Aircraft Lightning Environment			◇				
Publish Analytical Zoning Technique Report					◇		
Publish HIRF Protection Analysis Techniques Report							◇
Personnel and Other Costs	\$1,443						
Total Budget Authority	\$4,109	\$3,844	\$4,109	\$4,208	\$4,329	\$4,474	\$4,642

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority (\$ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	1,368	705	1,494	1,943	2,666
Personnel Costs	577	1,127	973	1,744	1,349
Other Costs	118	231	152	157	94
Total	2,063	2,063	2,619	3,844	4,109

A06e Aging Aircraft

GOALS:

Intended Outcomes: The FAA intends to improve aviation safety by developing technologies, technical information, procedures, and practices that ensure the continued airworthiness of aircraft structures and components in the civil transport fleet. The aging aircraft research program focuses principally on:

- Analytical methodologies development and validation to predict the onset of widespread fatigue damage (WFD) and residual strength of aircraft structures.
- Nondestructive inspection (NDI) techniques development and validation to detect and quantify damage in the forms of corrosion, cracking, disbonding, and material processing defects.
- Flight and landing loads airworthiness standards updates and validation by acquiring/analyzing actual usage data for civil transport aircraft.
- Maintenance and repair requirements and procedures establishment for airframes.
- Crack growth based predictive methodology development to derive inspection and maintenance programs for non-rotating, safety critical components of aircraft engines.
- Damage tolerance methodology, health/usage monitoring methodology, and updated design load spectrums (based on actual usage) for the rotorcraft fleet.
- Aging nonstructural systems research. The development of information, technology and techniques to ensure the continued safe operation of aircraft electrical and mechanical systems.

Agency Outputs: The FAA establishes rules for aircraft certification, inspection, maintenance, and repair and publishes Advisory Circulars (AC) to outline acceptable means for compliance. Additionally, the agency disseminates technical information in various forms to its airworthiness inspectors and to industry. These outputs improve aircraft construction and maintenance practices. The objective of all of these products is to improve flight safety by increasing the continued

airworthiness of aircraft. The aging aircraft research program provides the technical information necessary to support these agency outputs.

Customer/Stakeholder Involvement: The FAA has established an extensive network for collaboration in aging aircraft, including:

- The Aviation Rulemaking Advisory Committee (ARAC) is a FAA/industry forum established to ensure that industry's resources are used to their fullest extent and that the agency's rulemaking achieves intended results. ARAC also identifies requirements and priorities for supporting R&D activities.
- The FAA-sponsored Technical Oversight Group on Aging Aircraft (TOGAA) ensures effective coordination of aging aircraft program activities with related activities in Department of Defense (DOD) and industry. TOGAA meets several times a year to assess program progress and review research priorities in light of technical progress and the needs of aircraft manufacturers, operators, and maintainers.
- The Subcommittee on Aircraft Safety of the FAA Research, Engineering and Development Advisory Committee completed a review of the aging aircraft program. The program described here is fully responsive to the advice of the subcommittee.
- The aging aircraft program directly supports the Aviation Safety Research Act of 1988 (Public Law 100-591). This Act increased the scope of the FAA's mission to include research on methods for improving maintenance technology and detecting the onset of cracking, delamination, and corrosion of aircraft structures. In particular, this legislation directed the FAA to focus attention on maintaining the airworthiness of the aging commercial fleet.
- The aging nonstructural systems research program is the primary vehicle for supporting the recommendations of the White House Commission on Safety and Security, which states that "in cooperation with airlines and manufacturers, the FAA's Aging Aircraft Program

should be expanded to cover non-structural systems.”

Accomplishments: Completed in 1998, the Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) facility, located in the Safety Research and Development area at the FAA William J. Hughes Technical Center, is capable of testing full-scale curved panel specimens under conditions representative of those seen by an aircraft in actual operation. The data obtained from the tests will be used to validate analytical models being developed by the FAA. All testing is monitored using state-of-the-art video equipment for continuous observation. The test system, developed under contract with the Boeing Company, Long Beach, CA, features a unique adaptation of mechanical, fluid, and electronic components. It will be capable of applying pressurization, longitudinal, hoop, and shear loads to a curved panel test specimen.

The FAA’s Airworthiness Assurance Nondestructive Inspection Validation Center (AANC), located in Albuquerque, NM, continues to expand. The Center has specialized in the performance of comprehensive, independent, quantitative evaluations of new and enhanced NDI, maintenance, and repair techniques. The hangar facility contains several aging aircraft, large fuselage sections, and a sample structural defect library. Aircraft test articles include a B-747, B-737, DC-9, HU-25A, Fairchild Metro II, UH-1H, and TH-57 aircraft.

Civil transport flight and ground loads data collection programs for large as well as small transport aircraft have been reestablished. To collect flight loads data, optical quick access recorders have been installed on several B-737, B-757, B-767, MD-82, and A-320 aircraft, and usage data is being analyzed. Similar recording technology is being employed to collect data on BE-1900D and CRJ commuter aircraft.

The FAA is conducting a series of video landing parameter surveys at high capacity commercial airports to better understand typical contact conditions for a wide variety of aircraft and airports and how they relate to current aircraft design criteria and practices. Airplane landing contact parameters have been obtained from the analysis of video images recorded during surveys conducted

at representative high activity commercial large transport and commuter airports. To date, five such surveys have been completed at John F. Kennedy International Airport, Washington National Airport, Honolulu International Airport, London City Airport in the United Kingdom, and Philadelphia International Airport. Recently, a four camera video landing survey facility was established at the Atlantic City International Airport to collect landing usage data to characterize both fair and poor weather operations.

R&D Partnerships: Program activities are closely coordinated with related initiatives underway in industry and at NASA and DOD. The FAA, DOD, and NASA have cosponsored several conferences in the area of aging aircraft and airworthiness assurance. Interagency agreements are in place between the FAA and NASA, U.S. Navy, U.S. Air Force, and Department of Energy (DOE). International agreements are in place between the FAA and the regulatory authorities in the United Kingdom, the Netherlands, Australia, and Canada. A Memorandum of Cooperation is in place between the FAA and Russia.

The FAA Center of Excellence for Airworthiness Assurance (AACE), established in FY 1997, was formed with a broad mission in aircraft and aircraft systems safety research. AACE is a consortium consisting of eight core universities, Sandia National Laboratories, and more than 100 affiliates from government, industry, and academia.

The Center for Aviation Systems Reliability (CASR) is a consortium of four universities, Iowa State University, Northwestern University, Wayne State, and Ohio State University, formed to develop NDI techniques.

The Airworthiness Assurance Nondestructive Inspection Validation Center (AANC) is a partnership with Sandia National Laboratory to test and evaluate inspection techniques in a realistic hangar environment and enhance technology transfer.

The Engine Titanium Consortium (ETC), is comprised of Iowa State University, Pratt & Whitney, General Electric, and Allied-Signal; it was formed to develop methods for the inspection of engine components.

Numerous research grants have been awarded and are in place with universities and not-for-profit

laboratories to leverage their interests and capabilities. Cooperative research and development agreements (CRDAs) are in place with several airline operators as part of the flight loads data collection program.

**MAJOR ACTIVITIES AND ANTICIPATED
FY 2000 ACCOMPLISHMENTS:**

- Completed development of an engineering manual with guidelines to predict the onset of widespread fatigue damage (WFD) and residual strength and structures.
- Initiated an FAA-industry jointly funded study to conduct a destructive investigation of an aging aircraft to evaluate its susceptibility to WFD.
- Developed user friendly software tool for damage tolerance analysis and design of aircraft repairs for commuter aircraft.
- Enhanced a general purpose damage tolerance computer program, NASA Growth (NASGRO), to assess the structural integrity of commercial aircraft.
- Conducted research on new Digital Flight Data Recorder (DFDR) criteria to accurately characterize control surface movement.
- Published flight loads data reports for various transport and commuter aircraft models.
- Published landing load data reports from video landing parameter surveys.
- Together with industry, performed supplemental nondestructive and destructive testing on wiring system components.
- Concluded testing of aged circuit breakers to determine if the performance of these circuit breakers has degraded below the original manufacturer's specification.

- Develop a prototype testing or inspection device to identify hazardous conditions involving aircraft wire.
- Develop first generation, prototype arc fault circuit interrupter for aircraft applications.

**KEY FY 2001 PRODUCTS AND MILE-
STONES:**

- Continue enhancement to user-friendly software tool for damage tolerance analysis and design of aircraft repairs for commuter aircraft.
- Continue the FAA-industry jointly funded investigation of the susceptibility of an aging airframe to WFD.
- Continue development and validation of enhanced inspection systems for engine components.
- Continue development and validation of inspection techniques to detect damage in airframe structures typical of widespread fatigue damage.
- Continue flight and landing loads data collection, analysis, and reduction for large transport and commuter aircraft.
- Complete a report on the destructive testing of flight control linkages.

FY 2001 PROGRAM REQUEST:

In FY 2001, the program continues to focus on the areas listed at the beginning of the GOALS section above. The near-term emphasis is on a better understanding of the effects of widespread fatigue damage, developing supplemental inspection requirements to better account for airframe and component damage, developing and validating enhanced inspection techniques, and understanding the effects of aging on nonstructural systems.

2000 FAA NATIONAL AVIATION RESEARCH PLAN

A06e - Aging Aircraft Product and Activities	FY 2001 Request (\$000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
065-110 Aging Aircraft							
WFD and Residual Strength Analysis	\$7,349						
Completed Development of an Engineering Manual with Guidelines for Onset of Widespread Fatigue Damage (WFD)	◆						
Initiated Destructive Examination of Aging Airframe	◆						
Complete Destructive Examination of Aging Airframe and Publish Results					◇		
Continue Development & Validation of Inspections Techniques	◆	◇	◇	◇			
Develop Prototype for Detection of WFD-Size Cracks						◇	
Commuter Aircraft Requirements	\$1,012						
Develop and Continue Enhancement of User Friendly Software Tool for Damage Tolerance Analysis and Design of Aircraft Repairs for Commuter Aircraft	◆	◇	◇				
Enhanced General Purpose Damage Tolerance Computer Program to Assess the Structural Integrity of Commercial Aircraft	◆						
Airborne Data Monitoring Systems	\$1,540						
Publish Technical Report and Continue Data Collection Analysis on Flight Loads	◆	◇	◇	◇	◇	◇	◇
Conduct Video Landing Parameter and Loads Survey at Philadelphia, Denver and Other Airports	◆	◇	◇	◇	◇	◇	◇
Published Flight Loads Data Reports for Various Transport and Commuter Aircraft Models	◆						
Inspection for Engines	\$3,597						
Continue Development and Validation of Enhanced Inspection Systems for Engine Components		◇	◇	◇	◇	◇	◇
Complete Development of Ultrasonic Inspection Tools for Engines						◇	
Rotorcraft Structural Integrity	\$822						
Complete Final Health/Usage Monitoring System (HUMS) Advisory Circular (AC) and Compliance Guidance for Part 29 & 27 Rotorcraft							◇
Update AC 29-2A and 27-1 for Fatigue and Damage Tolerance							◇
Aging of Nonstructural Systems	\$4,003						
Concluded Circuit Breaker Testing on Performance Degradation	◆						
Performed Testing on Wiring System Components	◆						
Develop First Generation, Prototype Arc-Fault Circuit Interrupter for Aircraft Applications	◆	◇	◇	◇			
Complete Assessment of Feasibility of Service Life for Aircraft Wire	◆	◇	◇	◇			
Develop a Prototype Testing or Inspection Device to Identify Hazardous Conditions Involving Aircraft Wire	◆	◇	◇	◇			
Complete a Report on the Destructive Testing of Flight Control Linkages		◇					
Personnel and Other Costs	\$4,061						
Total Budget Authority	\$22,384	\$21,594	\$22,384	\$22,752	\$23,251	\$23,886	\$24,671

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority (\$ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	10,585	18,466	11,945	17,714	18,323
Personnel Costs	2,742	2,551	2,381	3,547	3,451
Other Costs	562	532	368	333	610
Total	13,889	21,549	14,694	21,594	22,384

A06f Aircraft Catastrophic Failure Prevention Research

GOALS:

Intended Outcomes: The FAA intends to improve system safety by developing technologies and methods to assess risk and prevent potentially catastrophic defects, failures, and malfunctions in aircraft, aircraft components, and aircraft systems.

The aircraft catastrophic failure prevention program focuses principally on using historical accident data and National Transportation Safety Board (NTSB) recommendations to examine and investigate known problem areas, such as:

- Turbine engine uncontainment events, including mitigation and modeling of uncontainment and aircraft vulnerability to uncontainment (AC20-128, phase II).
- Propulsion malfunctions and potential solutions with the help of industry.
- Explosive fuel tank issues, where the current focus is on the Fuel Quantity Indication System wiring and the impact of sulfide deposits.
- The accurate modeling of turbine engine imbalance.

Agency Outputs: The FAA establishes certification criteria for aircraft and publishes Advisory Circulars (AC) to outline acceptable means for meeting these rules. The program's objective is to ensure safe aircraft operation in the public domain.

The aircraft catastrophic failure prevention program provides the technical information necessary to support these agency outputs.

Customer/Stakeholder Involvement: The FAA continues to establish collaborative efforts such as the following to ensure a balanced, responsive aircraft catastrophic failure prevention program:

- The Aviation Rulemaking Advisory Committee (ARAC) is a FAA/industry forum established to ensure that agency rulemaking achieves intended results, and that the resources of industry are fully utilized in accomplishing these results. ARAC also identifies requirements and priorities for supporting R&D activities. The ARAC Powerplant Installation and Harmonization Working Group

(PPIHWG) provides guidance to this program for the update of AC20-128.

- The FAA sponsors a series of workshops on turbine engine uncontainment characterization, modeling, and mitigation. This forum brings together industry and government (civil and military) to review progress to date on this subject and to recommend future courses of action.
- The FAA has developed partnerships with industry through the ARAC Power Plant Installation Harmonization Working Group to collaborate in developing a modeling toolkit for the modeling of engine uncontainment events.
- The FAA supports the Aerospace Industries Association (AIA) - Transport Committee (TC) project examining propulsion system malfunctions and inappropriate crew response. This project brings industry and the FAA together to recommend courses of action to foster safety and to develop associated regulations and advisory materials.
- The ARAC Fuel Tank Harmonization Working Group provides guidance to this program on issues related to fuel tank explosions.
- The program also responds to Public Law 100-591 (the Aviation Safety Act) and Public Law 101-508 (the Omnibus Reconciliation Act), which together established the aircraft catastrophic failure prevention program.

Accomplishments: Results of the catastrophic failure prevention program research are provided to certification officials to form the technical basis for rule changes as well as new or modified ACs. Results are also provided to airframe and engine manufacturers and designers. Recent accomplishments include:

- Developed the uncontainment data base and experimental test data needed by ARAC to develop new guidance for uncontained turbine engine failure methodology.
- Developed improvements to an aircraft vulnerability model to predict aircraft vulnerability to engine uncontainment events.

- Interagency Agreement with NASA Glenn for cooperation on turbine engine uncontainment.

FY 2000 ACCOMPLISHMENTS:

Engine Uncontainment Research. ... equations for aluminum and titanium.

Engine Uncontainment Research.

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

- Developed an aircraft vulnerability model improvement plan and continue to make model improvements in cooperation with ARAC.
 - Budget Authority
 - Personnel Costs
 - Other Costs
- Initiate expansion of the advanced material DYNA 3D model to include failure modes and fabric interaction identified in system impact testing.

2001 quest (00)	Issued interim report on problem of copper-silver sulfide contamination on fuel quantity indicating system.					
	Program Schedule:					
	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
235	KEY	FY	2001	PRODUCTS AND		
	MILESTONES					
	◆	◇	◇			
	Engine Uncontainment Research.					
	•	Continue modifications to vulnerability code based on airframe manufacturers' evaluations.	◇			
	•	Complete work on a calibrated design tool to	◇			
427	◆	model engine uncontainment debris impact with titanium and aluminum aircraft materials.		◇		
	Propulsion Malfunction					
		◇				◇
475	Develop a plan for producing engine malfunction materials in conjunction with Flight Standards.					
	◆	◇	◇			
	Explosive Fuel Tank Issues.					
	•	Continue research into explosive fuel tank issues, focusing on the formation of sulfidation products in fuel tanks.		◇		
FY 2001 PROGRAM REQUEST:						
The program continues to modify aircraft vulnerability codes to incorporate suggestions obtained from airframe manufacturers' evaluations. It continues developing a calibrated design system, for certification purposes to						
645	examine engine uncontainment by developing toolkit components that model mitigation effects of advanced materials and improve penetration					
782	\$1,981	\$2,782	\$2,834	\$2,902	\$2,986	\$3,089

equations for aluminum and titanium:

- | | | | | |
|--|---|---|---|---|
| <ul style="list-style-type: none"> Developed an aircraft vulnerability model improvement plan and continue to make model improvements in cooperation with ARAC. Initiate expansion of the advanced material DYNA 3D model to include failure modes and fabric interaction identified in system impact testing. | <p>The program has developed engine malfunctions, including turbine engine surge.</p> <p>Lastly, the program will continue to be responsive to the ARAC Fuel Tank Harmonization Working Group in examining issues and potential solutions to the explosive fuel tank issue.</p> | | | |
| <p>Budget Authority</p> <p>2,450</p> <p>369</p> <p>75</p> <p>3,894</p> | <p>Enacted</p> <p>3,888</p> <p>590</p> <p>121</p> <p>4,600</p> | <p>Enacted</p> <p>1,330</p> <p>397</p> <p>61</p> <p>1,787</p> | <p>Enacted</p> <p>1,098</p> <p>607</p> <p>66</p> <p>1,991</p> | <p>Request</p> <p>2,327</p> <p>610</p> <p>35</p> <p>2,982</p> |

A06g Aviation Safety Risk Analysis

GOALS:

Intended Outcomes: The FAA will continue to increase its collaboration with industry in their mutual search for programs and systems with true potential for increasing aviation safety. Accordingly, the partners will build on their previous collaboration to improve risk assessment, safety performance measurement and the shared use of safety related data. The Aviation Safety Risk Analysis (ASRA) program focuses primarily on:

- Design/Development and/or enhancement of risk management/decision support tools embedded in FAA analytical systems, e.g., flight standards service Safety Performance Analysis System (SPAS), and the aircraft certification service safety management program products. These tools encompass particulars about air carriers, aircraft design, aircraft maintenance, discrepancy reports, repair stations (both domestic and foreign) aviation training schools, and air personnel.
- Development of advanced risk assessment indicators/safety performance measures and graphical techniques. These allow the FAA to more effectively and efficiently use information contained in various FAA and industry databases.
- Establishment of a forum with industry to exchange aviation risk assessment/risk management and safety performance measures models and methodologies.
- Establishment of a systems engineering and system safety risk assessment effort in support of certification, surveillance, investigation, and certificate management.
- Development of a safety analysis methodology that will be used first to certify new products in light of continued airworthiness issues and then to deploy those products under test conditions to increase the operational safety of the fleet.
- Development of a risk based tool to manage aircraft certification workload and prioritize oversight activities related to manufacturers.
- Development and/or enhancement of the Maintenance Malfunction Information Reporting (MMIR) System with capabilities to

track critical helicopter parts, to capture part utilization/performance data, and to perform trend analysis on the captured data.

- Development of guidelines for evaluating U.S. military surplus flight safety critical aircraft parts for installation on FAA U.S. type certified products.
- Development of a methodology for performing large scale software system reliability prediction and testing cost measures.

Agency Outputs: The Federal Aviation Act of 1958 and the Federal Aviation Regulation (FAR) provide the FAA the statutory authority and responsibility to conduct surveillance of air operators, air agencies, aircraft, and airmen to ensure conformance with the FAR and aviation safety standards. The outputs from the Aviation Safety Risk Analysis research program improve the data, data gathering techniques, analysis, and risk management/decision support tools needed for FAA certification, surveillance, investigation, and certificate management processes. These outputs enable systematic risk assessment and safety performance measurement to take proactive steps to reduce the rate of aviation-related accidents and incidents. Based on insights from risk analysis, the FAA targets and increases its leverage of aviation safety inspector and certification engineering resources.

Customer/Stakeholder Involvement: The Federal Aviation Authorization Act of 1996 requires that the Administrator give "high priority to developing SPAS." The legislation calls for deployment of SPAS II, initiated in FY 1997, to be completed by December 1999. ASRA enhances SPAS decision support capabilities through additional risk analysis/predictive models, expert system capabilities, and critical safety performance indicators.

In 1997, the Flight Standards Service introduced their new business process, the Air Transportation Oversight System (ATOS); a system based approach to FAA certification, surveillance, and certificate management oversight. ATOS is designed to provide the FAA with the people, procedures, equipment, facilities, software, tools, and materials necessary to make surveillance

more systematic and better targeted to deal with identified risks. The ASRA program will provide systems engineering; analyses in the form of design of safety performance measures, data sources, analysis methodologies, information presentation; and system safety risk assessment research (such as hazard analysis, design of risk indicators, Markovian Models, and Aviation System Risk Models) in support of this effort.

The ASRA Program responds directly to the Safer Skies Agenda, recommendations in the Challenge 2000 Report and the FAA 90-day Safety Review. Maximum information sharing alerts both the FAA and industry to pending aviation safety related problems. Developing a certification and surveillance program built on targeting resources to address safety risks ensures that corrective action is taken much sooner. Thus, the primary beneficiaries of this effort are the general flying public.

Several analytical tools, such as SPAS, will be used by the Department of Defense in their oversight of defense contract carriers and charters.

The FAA worked with Helicopter Association International to develop and release the maintenance malfunction information reporting system. This software tool has improved the collection, storage, and transfer of service difficulty reports and part warranty information.

Data improvement and standardization efforts respond to recent Congressional hearings and the General Accounting Office (GAO) report recommendations that the FAA increase the quality and timeliness of their aviation safety data. More importantly, analytical and decision support tools rely on high quality data to identify potential safety risk areas.

Accomplishments: Full deployment of SPAS II was initiated in FY 1997 and was completed by December 1999. This is a computer based analytical tool used by FAA aviation safety inspectors and certification engineers, as well as DOD aviation analysts, to support the oversight activities of FAA certificate holders (i.e., air operators, air agencies, aircraft, and air personnel). A study was initiated to establish baseline risk parameters related to continued

airworthiness of aircraft and to analyze the factors which generally precede aircraft accidents.

R&D Partnerships: The U.S. Air Force Air Mobility Command provides technical support and assistance in developing safety critical performance measures. Discussions have been initiated with the Department of the Interior (DOI) regarding a partnership with DOI for sharing aviation safety data. An interagency agreement was established with the Department of Energy (DOE), enabling Sandia National Laboratories to contribute their technical expertise in developing system design, development, and safety, as well as safety performance measures, risk indicators, and the implementation of a data quality improvement strategy. The Air Carrier Operations System Model (FAR Part 121) will be developed with several major air carriers. The Helicopter Association International (HAI) continues to work with the FAA to develop and enhance the Web based Maintenance Malfunction Information Reporting (MMIR) system that now accepts data from helicopter on-board Health, Usage and Monitoring systems (HUMS) for safety analysis and condition based maintenance monitoring. Several university grants have been awarded to support the development and testing of aviation safety risk models. For example, Rutgers University is contributing to the development of the Intelligent Decision Support Tool and the Aviation System Risk Model.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Risk Management Decision Support

- Initiated the design of flight standards next generation safety critical performance measures and risk indicators based on system engineering and system safety models of FAR Part 121. These tasks were accomplished in conjunction with industry.
- Implemented new and enhanced risk analysis models and capabilities.
- Developed and incorporated safety critical performance measures into flight standards (SPAS II).
- Initiated a decision support system requirements study.

- Continued workshops with industry to discuss aviation risk analysis and safety performance measurement methodologies and tools.
- Continued to develop risk/hazard/accident models and tools based on FAR Part 121.
- Completed the development of a prototype Intelligent Safety Performance and Evaluation System.
- Initiated the development of the Aviation Safety Risk Management System.
- Released the Air Personnel Module.
- Conduct a repair station information requirements study and analysis.
- Release the Repair Station Component Prototype.
- Initiate the development of a system engineering model based on FAR Part 135 operations.
- Continue workshops with industry to discuss aviation risk analysis and safety performance measurement models and methods.
- Continue the development of the Aviation Safety Risk Management System.
- Initiate the design of decision support system options analysis.
- Continue the development of Risk/Hazard/Accident models and tools.

Aircraft Maintenance: Maintainability and Reliability.

- Completed FAA order on Eligibility and Evaluation of U.S. Military Surplus Flight Safety Critical Aircraft Parts, Engines and Propellers.
- Completed a handbook on Eligibility and Evaluation of U.S. Military Surplus Flight Safety Critical Aircraft Parts, Engines and Propellers.

Safety Analysis Methodology

- Initiate development of a methodology that will enable the Aircraft Certification Systems Evaluation Program (ACSEP) to focus on those areas statistically found to have the greatest impact on aviation safety.
- Initiate the development of probabilistic safety assessment efforts that address aircraft systems safety.

KEY FY 2001 PRODUCTS AND MILESTONES:

Risk Management Decision Support

- Continue to develop, test, and validate new and enhanced risk analysis models and capabilities.
- Continue to develop risk assessment indicators and safety critical performance measures using enhancements to the system engineering and system safety models based on FAR Part 121 in conjunction with industry.

Aircraft Maintenance - Maintainability and Reliability

- Initiate analysis in support of an Advisory Circular (AC) entitled, Eligibility and Evaluation of U.S. Military Surplus Flight Safety Critical Aircraft Parts, Engines, and Propellers.
- Enhance the Maintenance Malfunction Information Reporting (MMIR) System with capability to integrate with other aircraft safety monitoring system such as HUMS.
- Establish criteria for utilizing Built-in Test Equipment (BITE) as an approval for return aircraft to service.
- Complete an AC on inspection procedures regarding Flight Safety Critical Aircraft parts, engines and propellers.

Safety Analysis Methodology

- Continue the development of probabilistic safety assessment efforts that address aircraft systems safety.
- Integrate ACSEP improvement methodology into current system and develop software tools to deploy improvements to field.

FY 2001 PROGRAM REQUEST:

In FY 2001, research continues to focus on the areas listed at the beginning of the GOALS section above. Data assimilation, analysis, and tool development continue in support of ASRA initiatives. The analysts work with government, industry, and academia aviation safety subject matter experts to ensure that risk management/

decision support tools, including safety critical performance measures and risk indicators are properly defined, developed, tested, and evaluated prior to implementation. The program investigates, tests, and recommends

improvements, including standardization, to the quality (and quantity) of data used in the performance measures. It also completes studies to identify and verify flight standards and aircraft certification safety information requirements.

2000 FAA NATIONAL AVIATION RESEARCH PLAN

A06g - Aviation Safety Risk Analysis Product and Activities	FY 2001 Request (\$000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
060-110 Aviation Safety Risk Analysis							
Risk Management Decision Support	\$3,370						
Design Flight Standards Next Generation Safety Critical Performance Measures and Indicators Based on System Engineering and System Safety Models based on FAR Parts 121/135		◆	◇	◇	◇	◇	◇
Develop, Test, Validate and Enhance Risk Analysis Models and Capabilities		◆	◇	◇	◇	◇	◇
Develop and Implement Safety Critical Performance Measures into Flight Standards SPAS II		◆	◇	◇	◇	◇	◇
Conduct a Decision Support System Requirements Study		◆					
Conduct Workshops with Industry to Discuss Aviation Risk Analysis and Safety Performance Measurement Methodologies and Tools		◆	◇	◇	◇	◇	◇
Develop Risk/Hazard/Accident Models and Tools based on FAR Parts 121/135		◆	◇	◇	◇	◇	◇
Develop the Aviation Safety Risk Management System		◆	◇	◇			
Develop System Engineering Models Based on FAR Parts 121/135		◆	◇	◇	◇	◇	◇
Design the Decision Support System Options Analysis Model			◇	◇			
Release the Air Personnel Module			◇				
Develop Repair Station Prototype		◆	◇	◇			
Aircraft Maintenance: Maintainability & Reliability	\$600						
Completed Handbook on Eligibility and Evaluation of US Military Surplus Flight Safety Critical Aviation Parts, Engines, and Propellers		◆					
Establish Criteria for Utilizing Built-In Test Equipment (BITE)			◇				
Enhance the Maintenance Malfunction Information Reporting (MMIR) System			◇	◇	◇		
Initiate Analysis in Support of Advisory Circular: Eligibility & Evaluation of US Military Surplus Flight Safety Critical Aircraft Parts, Engines and Propellers		◆	◇	◇			
Develop MIS Data Base			◇				
Safety Analysis Methodology	\$480						
Develop and Integrate an Aircraft Certification Systems Evaluation Program (ACSEP) Improvement Methodology			◇	◇			
Develop Methodology for Comprehensive Safety Analysis of Aircraft Systems			◇	◇	◇		
Personnel and Other Costs	\$2,207						
Total Budget Authority	\$6,657	\$6,824	\$6,657	\$6,780	\$6,939	\$7,140	\$7,383

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority (\$ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	3,619	5,289	5,555	5,286	5,165
Personnel Costs	316	1,039	794	1,393	1,414
Other Costs	65	213	122	145	78
Total	4,000	6,541	6,471	6,824	6,657

